INVESTIGATIONS CONCERNING THE MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

(Progress Report Number 4)

Respectfully Submitted,

Archie L. Gibson

A. L. Gibson
Assistant Entomologist.

Forest Insect Field Station
Coeur d'Alene, Idaho

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PINE BEETLE IN LODGEPOLE PINE

CONTENTS

	Page
INTRODUCTION	1
INJECTION MATERIALS USED ON LODGEPOLE PINE INFESTED WITH D. MONTICOLAE IN SEARCHING FOR AN IMPROVED METHOD OF CONTROL	1
PROJECT IV-A-1 - POISONING INFESTED LODGEPOLE PINE TO KILL THE BROOD OF DENDROCTONUS MONTICOLAE	3
PROJECT IV-A-2 - THE DISTRIBUTION OF LIQUIDS IN LODGEPOLE PINE AS INDICATED BY STAINS	20
PROJECT V-A-4 - DICHLORIDE AS A CONTROL MATERIAL FOR THE MOUNTAIN PINE BEETLE	28
PROJECT V-A-3 - GREEN LODGEPOLE PINE HEATED WITH A BLOW TORCH TO ATTRACT MOUNTAIN PINE BEETLE	29
PROJECT VI-A-7 - BROOD DEVELOPMENT OF DENDROCTONUS MONTICOLAE IN LODGEPOLE PINE	31
SUMMARY	33

PROGRESS REPORT NUMBER 4

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INTRODUCTION

A serious epidemic of the mountain pine beetle has existed in western Montana for a number of years, where it has spread southward along the Continental Divide, killing as high as sixty per cent of the merchantable lodgepole pine and yellow pine timber over large areas. These losses and a threatened continuation of them made it advisable to initiate an intensive study of the insect to secure information upon which a more economical method of artificial control could be built, as well as a better understanding of the natural factors of control. The epidemic having become well established on the East Fork of the Bitterroot River in 1925, and that area being conveniently located for investigative work, the studies were begun there that year. At first many projects were undertaken but the discovery that a vast amount of data was required for each study, to secure an idea of representative conditions, made it necessary to greatly reduce the number of projects. Work during the 1929 season was confined to lodgepole pine.

INJECTION METHODS USED ON LODGEPOLE PINE INFESTED WITH DENDROCTONUS MONTICOLAE IN SEARCHING FOR AN IMPROVED METHOD OF CONTROL.

Lodgepole pine were treated with various chemicals and some variation in method in 1926 in an effort to control the brood of the mountain pine beetle. The chief method used, a modification of the Lipman-Gordon tree-injecting method, was to bore a one-inch hole through the tree, or at least

deep enough to tap the sapwood on the far side. If bored through, the hole on the far side was plugged with a tight-fitting cork. To the hole on the near side was fitted a cork containing a short piece of copper tubing, which was connected by a short length of rubber hose to a can fastened on the tree above the hole. The can contained the solution to be injected. In variations of the method the sapwood was tapped in from one to as many as six different places by a series of interconnecting holes. To make a fair test of the merits of these variations the same chemical should be used with all of them. This was done. The chemical selected and used for the test being sodium arsenate.

To make a fair comparison of the different chemicals only one method should be used. The method selected consisted of boring a one-inch hole entirely through the tree, plugging it on one side, and connecting the other end with the can holding the solution to be injected. By this method two areas of sapwood were made available for conduction of chemicals. Any departure from this general method is noted in the text and where no exception has been recorded the general method was the one used.

Because of its rapid evaporation upon exposure to the air, carbon disulphide was injected in a few trees by pouring the chemical into the holes and sealing all openings with corks. The possible loss by evaporation was thus greatly reduced.

In general, only negative results were obtained from the experiments by using this method but a few trees gave partial control which indicated that the fault lay not in the chemical used but in the method used and that modifying the present method might give positive results. Some modifications were tested in the late summer of 1929. The most promising one has been called the saw-kerf method. It consisted of making a cut in the sapwood of an

infested tree to a depth of about one-half an inch entirely around the tree about two feet above the ground, the cut being made with a cross-cut saw. Above and below the cut, for a few inches, the surface was trimmed until smooth and then coated with heavy grease. A band of inner tube about four inches broad was then laid over the saw kerf and wrapped around the tree until it covered the entire cut. The wrapping was then continued around the upper and lower edges of the first wrapping in an attempt to secure a tighter joint. The free end was then fastened to the tree by a tack or a shingle nail. Over a place where the saw kerf had been slightly enlarged by a knife or auger, a small hole was made in the rubber band and a short piece of copper tube inserted. This copper tube was then connected by a short length of rubber hose with the can containing the solution to be injected.

Results of these various experiments are given under separate headings on the pages that follow.

PROJECT IV-A-1

POISONING INFESTED LODGEPOLE PINE TO KILL THE BROOD OF DENDROCTONUS MONTICOLAE.

Injection by the Lipman-Gordon method.

Sodium Arsenate

Quantitative analyses were made by the Bureau of Chemistry and Soils of the sodium arsenate present in samples taken from lodgepole pine injected in 1927. From this statement, published in "Progress Report Number 3" of the Coeur d'Alene Forest Insect Field Station, it was found that

sodium arsenate was quite generally distributed over the entire tree. The doses injected in the trees analyzed were about two ounces of poison dissolved in from one to two quarts of water. The poison seemed to have no controlling effect on the bark-beetle brood. It was thought the amount of poison may have been insufficient and in 1928 the amount injected in each tree was increased to from five to eight ounces, fifty-seven trees being so treated. The number treated with the different amounts of poison is given in the following tabulation.

Sodium Arsenate Injected in Lodgepole Pine Infested With Dendroctonus Monticolae.
East Fork-Bitterroot River-1929

	Amount of Sodium Arsenate per Tree			Period When Treated in 1928	Period When Examined in 1929	Results of Treatment
	5 oz.	6 Oz.	8Oz.			
Number Treated	10	20	27	August 11	May	Slight control around injecting holes.
Examined Intensively	10	16	15	to	to	
Examined Extensively--		4	12	September 15	August	

In spite of the heavy doses very little control of the bark-beetle brood was secured. In most of the trees very small areas close to the injecting holes were the only places that showed any control. The reason for so little destruction of the brood is not clear but it is believed to be due to the poison not getting into the outer growth rings where the brood is present. Experiments conducted later in the season, in which the material was distributed in these rings, gave good control.

The number and development of brood in the forty-one trees treated with the arsenate varied little from that of thirty-four check trees examined at the same time and in the same areas as the treated trees. A comparison of these treated and control trees is shown in tabular form. In the title of the succeeding table the word "untreated" has been used instead of "control" because the latter is so often used to mean the destruction of brood in infested trees.

Comparison of Sodium Arsenate Treated and Untreated Lodgepole Pine Infested With Dendroctonus Monticolae.

East Fork-Bitterroot River-1929

	Number of Trees	Average Number Insects Attacking	Average Potential Emergence#	Per Cent Potential Emergence is of Attack	Average Inches of Gallery per Square Foot
Untreated Trees	34	21.5	18.0	79	92.1
Treated Trees	41	17.2	13.3	77	75.1

On basis of July 21, from curve

It may be seen from the tabulation just shown that the relation of the potential emergence to attack in both treated and untreated trees is almost exactly the same. While the figures given are subject to considerable variation they still indicate that injection of the poison by this method is ineffective as a control measure. Inspection of the preceding table also shows that the number of insects attacking and emerging, and the amount of egg gallery per unit of surface are all higher for the control than for the treated trees. The smaller amount in treated trees cannot be assigned to any effect of the poison but rather to the large normal variation found in different groups of trees.

It is recommended that further experiments with the Lipman-Gordon method, using sodium arsenate, be discontinued, but that the poison be tried with an improved saw-kerf method of injection.

Prussic Acid

Thirteen trees treated with prussic acid in 1928 were examined in 1929. The treatments they received and the results obtained are given in the table that follows.

PRUSSIC ACID INJECTED IN
LODGEPOLE PINE ATTACKED BY THE MOUNTAIN PINE BEETLE
EAST FORK - BITTERROOT RIVER
TREATED IN 1928 - EXAMINED IN 1929

Tree Number	Cubic Centimeters of Solution	Per Cent Strength of Solution	Arrangement of Injecting Holes In Sapwood	Date Examined	Results of Treatment
1-P-70	500	5	One side tapped	5/24	No control
1-P-76	850	3	Two sides tapped	7/15	" "
1-P-83	750	3½	One side tapped	7/15	" "
1-P-84	500	2½	One side tapped	7/15	" "
1-P-77	500	2	Two sides tapped	7/15	" "
1-P-72	1500	2	Two sides tapped	7/19	" "
1-P-79	850	3	Two sides tapped	7/19	" "
1-P-80	1000	2½	One side tapped	7/19	" "
1-P-73	500	3	? (1)	7/19	" "
1-P-71	1000	2½	Two sides tapped	7/22	" "
1-P-74	500	5	Two sides tapped	7/23	" "
1-P-75	1000	2½	Two sides tapped	7/23	" "
1-P-82	500	5	Two sides tapped	7/23	" "

(1) Recording overlooked

Considerable variation was noted in brood development, a condition which previous studies in untreated trees has shown to be normal. Variation in strength and quantity of the solution injected showed no visible effect. It seems plausible to again lay the failure to control the brood to the method of injection. It is not believed the chemical was given a fair test by the method used and favorable results with injecting experiments in the east make it inadvisable to reject the material. The saw-kerf method would probably give more favorable results and it is recommended that prussic acid be tested again when that method of injection is improved.

Carbon Disulphide.

In August of 1928 trees infested with the mountain pine beetle were treated with carbon disulphide. They were examined during the period from May to July of 1929. A general outline of treatment and results is given in the following table.

Carbon Disulphide Injected in
Lodgepole Pine Infested with the Mountain Pine Beetle.
East Fork - Bitterroot River
Treated in 1928-Examined in 1929

Tree Number	Cubic Cent. of Solution	Arrangement of Injecting Holes in Tree #	Date Examined	Results
1-C-4	500	One thru	5/21	No Control
1-C-7	800	" "	5/22	" "
1-C-46	1000	" "	6/12	" "
1-C-10	500	" "	6/27	" "
1-C-42	200	Two thru and interconnecting ##	6/28	" "
1-C-43	300	Three thru and interconnecting ##	7/8	Large lethal area-20 sq. feet
1-C-44	250	Two thru and interconnecting ##	7/8	Large lethal area-25 sq. feet
1-C-18	1000	One thru	7/10	Small lethal area-less than 3 sq. ft.
1-C-15	500	One thru	7/10	Small lethal area-less than 3 sq. ft.
1-C-21	500	One thru	7/11	No control
1-C-105	900	One thru	7/25	No control

One hole through the tree taps two areas of sapwood.

No can was used with these trees the holes being bored, the material poured in them and the holes then closed with a cork.

The amount of brood in the different trees showed great variation but averaged about the same as that for untreated trees. Treatment showed no uniformity in its effect on the insects. Some trees were found to have a fairly large lethal area while others similarly treated gave no indication of any brood control. That carbon disulphide is effective in controlling the brood is shown by the presence of varying sized areas near the injecting holes within which the brood has been killed. The amount of material injected in a tree was no index of the absence, presence or size of lethal areas. The trees having the largest lethal areas had comparatively small doses, while most of the trees receiving the large quantity had no such areas. In general, injection of carbon disulphide by the Lipman-Gordon method did not cause as large lethal areas as where holes were bored in the tree, the material poured in, and the holes then plugged with corks. No significance should be attached to this difference, however, because of the great variability of results with both treatments.

A curve plotted of the brood development in trees treated with carbon disulphide revealed an average potential emergence practically the same as the number of insects attacking.

It is believed some discussion of the lethal areas should be presented. In some of these areas, especially near the injecting holes, eggs had not even hatched in the egg galleries. A little further from the holes they had hatched and the larvae had completed a little development before dying. Increasing amounts of growth prior to death were noted as the distance from the injecting holes increased, indicating that the spread of the poison had been slow to the outer edges of the lethal zones or else that the effect of the poison was cumulative. If the latter is true, the gradations in development, prior to death, on different areas is readily understood. More feeding would be necessary near the limits of the spread of the poison before an insect could accumulate enough poison to prove fatal, than

close to the hole where the concentration of poison would be much greater.

Failure to give uniform or general control makes it necessary to reject the method but not the material as a medium of control. The experiment did indicate that carbon disulphide is lethal to the mountain pine beetle.

Continuance of experiments with the methods just discussed is not believed to be justified. It is recommended, however, that carbon disulphide be tried with improved methods of saw-kerf injection.

Sodium Hydroxide

Each of two mountain pine beetle infested lodgepole pine had a solution of three ounces of sodium hydroxide dissolved in a quart of water injected in them in 1928. When examined in May and July of 1929 the brood showed no apparent effect of the treatment even immediately above and below the points of injection. Had there been any effect from the treatment, experience with other materials indicates that it would have been noticeable at these points.

In view of the negative results obtained it is not recommended that sodium hydroxide be used again with this method, but that it be given a trial with the saw-kerf method of injection.

Hellebore

Hellebore, to the amount of two ounces mixed with two quarts of water in one tree and an ounce to a quart in each of two other attacked trees, was injected in lodgepole pine in 1928. The greater part of the powdered material did not dissolve. When examined in May and July of the following year (1929) none of the trees showed any effect of the material on the brood. It is not

recommended that any further experiments be conducted with hellebore, using the method of injecting just discussed, but that it be considered for injecting with the saw-kerf method.

Black Leaf "40" (Nicotine Sulphate)

Nicotine sulphate used in the same manner and number of trees as in the preceding experiment indicated possible control on only one very small area immediately above an injecting hole, when the trees were examined in 1929. Brood development elsewhere seemed entirely unaffected.

It is not recommended that any further experiments be conducted with this method, but it is believed that the material offers possibility of control with the saw-kerf method of injection.

Potassium Cyanide

Believing that adding to the number of injecting holes in attacked trees might increase the number of lethal areas sufficiently to include the entire diameter of the tree, injection was tried with a varying number of interconnecting holes. The data and results are given in condensed form in the following tabulation.

Potassium Cyanide Solution Injected in Lodgepole Pine
Infested with Dendroctonus Monticolae

East Fork - Bitterroot - 1929

Tree No.	Oz. of Poison	Arrangement of Injecting Holes *	Results
2-K-1	4	Four thru and interconnecting	Not examined.
2-K-2	4	Two thru and interconnecting.	At 12" above point of injection 6" out of 32" of the circumference was lethal. Foliage sorrel in color.
2-K-3	4	Two thru and interconnecting.	At 6' above the point of injection 11" out of the 20" of infested circumference was lethal. Lethal zone extended to height of infestation, 20'. Part of foliage fading, rest green.
2-K-4	4	Four chiefly tangential and interconnecting.	Practically no lethal area beyond 18" above points injected.
2-K-5	4	Three thru and interconnecting.	Lethal areas only as wide as injecting holes, at 18" above injection.
2-K-6	4	Three thru and interconnecting.	Not examined.
2-K-7	2	Two thru and interconnecting.	Not examined.
2-K-8	2	Two thru and interconnecting.	Not examined.

* Each hole bored through the tree taps two areas of sapwood which is the conducting tissue.

Data common to all trees treated was as follows:
(1) Amount of solution equalled two quarts.
(2) All treated on August 3, 1929.
(3) The examinations discussed were made on September 23, 1929.

From experiments in which stains had been injected in green trees for the purpose of studying the distribution of liquids by the method just discussed, it was found that the stained area seldom exceeded the injecting hole in width. In attacked trees, however, lethal areas were generally larger than the injecting holes, seeming to indicate that insect work was either directly or indirectly responsible for some lateral diffusion of the poison. This tendency to show larger lethal areas was not uniform and in some trees none whatever were present. The uncertainty of results makes it inadvisable to consider increasing the number of injecting holes for poison solutions in a tree as a possibility of controlling bark beetles.

Picric Acid

On June 21 a tree attacked in 1928 was treated by boring two holes entirely through the tree at right angles to each other and injecting the solution in them using the Lipman-Gordon method. The green sides of the tree showed a limited distribution of the yellow stain caused by this material, the maximum being five feet above the point of injection. On the sides having the blue stain, which were heavily attacked, no distribution of the poison occurred, if the absence of the yellow stain is an indication. Where absorption did occur, on the green sides, the stained zone was only the width of the injecting hole immediately above that place and tapered to a point at the extreme height of diffusion. If the presence of the stain is a true indication, the sapwood was the only part of the bole that carried the liquid.

Observations made of trees heavily blue stained showed that such trees do not absorb liquid as rapidly as those less heavily stained. Sides of attacked trees which were still green and had little or no stain show even more rapid absorption of liquid, indicating that degree of blue stain and speed of liquid absorption bear a close relation. This relation is only indicated, an explanation of the phenomenon being left to specialists who are now giving blue stains an intensive study.

The use of picric acid in the Lipman-Gordon method should be discontinued but it should be given a trial with the saw-kerf method.

Hack-girdling Between Injecting Holes as a Means of Increasing Lethal Areas in Poisoned Trees.

Mr. W. W. White, Assistant District Forester, Missoula, Montana, and Mr. J. C. Evenden of the Coeur d'Alene Forest Insect Field Station, in the course of a discussion evolved the following idea on control by the injection method.

The substance of the conversation leading to the idea was as follows: Fire at the base of a green tree often results in a killed area which develops into a scar. The area above the burn does not die, nourishment presumably being furnished it by the undamaged area adjacent, by lateral translation. Following burning, the tree immediately starts to heal over the killed area by sending out new cambium from the edge of the burn. Eventually the scar is likely to be healed over although many years may elapse before that occurs. If materials are conveyed laterally in tissue over scars it seems reasonable to suppose that the artificial wounding of the tree might result in the same action. If so, severing the tissue between injecting holes should cause lateral distribution above the holes of any material injected in them. Following that line of reasoning, on August 27, 1929, four trees attacked by the mountain pine beetle were bored, potassium cyanide solution injected, and the sapwood in between each hole to the depth of one half inch was cut with a small hand axe.

Felling and intensive examination of one of these trees and extensive inspection of three others failed to prove the theory to be sound. The distribution was very similar to that which occurred in trees in which the interval of sapwood had not been severed. However, the three trees extensively examined and a few not inspected are to be studied more closely during the 1930 season to determine if any radial or circumferential distribution of poison has occurred subsequent to the examinations made in September, 1929. Other trees, treated with potassium cyanide in various ways, are also to be intensively studied. When numerous injecting holes are made in a tree it is possible that lateral or radial diffusion, not noticed soon after treating, may take place gradually and by spring result in the control of the brood.

Such a condition seems to have occurred in a few cases in trees treated in

1928. In one case a tree treated with four ounces of potassium cyanide dissolved in two quarts of water had been injected through the medium of a one-inch hole bored entirely through the tree and making available two areas of conducting tissue. This tree had two lethal areas at the base, with the injecting holes as centers, which amounted to practically 40 per cent of the total circumference at the broadest part of the lethal zone. These no life areas diminished in size with increasing height on the tree but no living brood was found until practically the upper limit of these areas had been reached. The lethal area on the north side of the tree extended to about twelve and on the south to about twenty-two feet. Two suggestions are offered for this unequal distribution of solution. More advanced development of blue stain on the north side of the tree may have retarded absorption of the solution on that side. There may have been greater cambium and sapwood activity on the south side of the tree due to higher temperature and causing absorption of more of the solution. Four other trees in which carbon disulphide had been injected also had areas on which the brood had been unable to develop. Lethal areas on them varied in width to a maximum of five or six inches.

Comparison of the Brood on Injected and Untreated Sides of the Basal Section of Lodgepole Pine Treated by the Lipman-Gordon Method.

None of the poisons injected by this method gave at best more than partial control. There did seem, however, to be some effect from the poison in the basal section of most of the trees, an amount too small to be considered significant in the individual tree but possibly showing some definite tendency when considered collectively. To determine if such a condition existed, examinations were made of treated trees at a height of

about five feet above the ground. It was believed this basal section of the tree would show the effect of the poison if any had been secured because the injection was usually made at approximately four feet above the ground and any concentration of poison should be heaviest just above the point of injection. The samples of bark examined were one foot long and three inches broad. Two of them were taken just above the points of injection and the other two at the same height on the sides between and consequently most remote from the points of injection. The trees examined comprised those that had been treated with sodium arsenate, prussic acid, carbon disulphide, and potassium cyanide. In 47 out of the 63 trees examined it was found that the sides injected had proportionately a smaller brood than the sides remote from injection. The fact that this relation existed in about 75 per cent of the trees examined seems to establish that there was a definite controlling effect by the poison. The brood conditions in injected and remote sides is shown in a tabulation immediately following.

Comparison of Brood in Treated trees for Sides Adjacent to and Remote from Injecting Holes.
Comparisons for Basal Sections Only.
East Fork ---- Bitterroot----1929

Number of Injected Sides Having	Treatment: Sodium Arsenate	Prussic Acid	Carbon Disulphide	Potassium Cyanide	Totals
Less Brood than Remote Sides	22	6	9	10	47
More Brood than Remote Sides	6	4	2	4	16
	28	10	11	14	63

From the tabulation just given it is seen that, with the exception of the prussic acid treatment, there is a decided majority of trees showing less brood on the injected sides. Subsequent experiments verify the finding that at least some of the poisons will control the brood when it can be gotten into the outer rings of the sapwood. In later experiments, where injection was confined to the outer rings, sodium arsenate gave good control.

Injection by the Saw-Kerf Method

Sodium Arsenate.

From experiments conducted earlier in the summer of 1929 in which stains were injected in trees to study the distribution of liquids, it was found that the saw-kerf method gave the most general diffusion of solutions in the outer rings of the sapwood. It was decided to test the method on newly attacked trees to secure a better index of its effectiveness as a bark beetle control measure. This was done on two newly attacked trees on July 29, using a solution of four ounces of sodium arsenate dissolved in two quarts of water. On August 3 one of these trees showed fading foliage, indicating that the poison was being very generally distributed. On September 23 one of the two trees was felled and intensively examined over practically the entire infested length. No living stage of the mountain pine beetle was found above the point of injection. A few living roundhead borers were found, however. Blue stain was present in only a few places and over small areas above the saw kerf. Eggs had not even hatched and the parent adults were dead.

Below the saw kerf, from within eight inches of the injecting point to the ground, the insects were making normal development and a small proportion had even reached the pupal stage. The line between normal and no development, which was believed to indicate the limits of the effect of the poison, was surprisingly definite. Complete blue staining of the sapwood was noted below this point. The foliage of this tree was as red as that of trees attacked the previous year, due to fading probably caused by the poison.

The other tree treated in the same manner was left standing and given only an extensive examination as it was desired to postpone more detailed study of it until the 1930 season. The extensive inspection indicated the same excellent control of the infesting brood as was noted in the first tree.

It is apparent from the data just given that sodium arsenate when injected in a tree so it is taken up by the outer growth rings, will control the brood infesting the tree. While it is only an experimental success at present, the method offers possibilities for development into an economical control measur

CONCLUSIONS AND RECOMMENDATIONS

A brief summary of the results of the preceding experiments shows the Lipman-Gordon method even when most effective, gave only very limited control. The value of the method is further discounted by variability in results, it being not unusual to find adjoining trees, similarly treated, showing partial control of brood in one case and none whatever in the other. Injection by the saw-kerf method has been very successful in controlling the mountain pine beetle but the technic of application needs a great deal of improvement before it can be given consideration as an economical method.

As a general recommendation it is believed advisable to discontinue all injecting experiments with the Lipman-Gordon method and concentrate on improving the saw-kerf method. The former has proved inadequate to secure the desired results, the latter gives considerable promise as a successful control method.

In seeking to improve the saw-kerf method the following suggestions have been made and should be given a trial during the coming season.

(1) A waxed paper collar. After making the usual saw-kerf cut to a depth of one-half inch in the sapwood the bark for two inches below the cut should be trimmed until a smooth surface is secured. To this surface should be tacked the lower edge of a collar of heavy waxed paper or light cardboard about five inches broad. The paper collar should flare outward until the upper edge is about one inch from the bole of the tree. Into the V-shaped junction of collar and tree, melted paraffin or some other caulking material should be poured until it reaches the level of the saw kerf. It is believed the waxed paper and the paraffined joint will prevent leakage of solutions poured into the collar. The solution to be injected is then poured into the collar until it reaches a level about one-half inch above the saw kerf. To insure a continuous and adequate supply of liquid until the required amount

has been absorbed, a tightly covered can or fruit jar containing the solution is to be suspended above the collar. By having it air-tight and a rubber hose connection from the bottom of the receptacle to the level of the liquid in the collar, that level can be maintained sufficiently constant to serve the purpose of the experiment. When absorption of liquid by the tree lowers the level of the liquid in the collar below the end of the hose, air is admitted to the can and displaces the solution in the receptacle causing it to flow until the surface of the liquid in the collar is once more above the level of the end of the hose. This is repeated as the solution is absorbed until the can is drained. Retention of most of the solution in the collar is believed necessary because the weight of the full amount of liquid on the paper collar at one time probably would break the water tight joint between caulking and collar. A small amount of solution maintained at a constant level in the collar is less likely to impair its effectiveness.

(2) A broad waxed paper collar. A further modification of this method is to use a waxed collar of heavy material from eight to ten inches broad, fastened to the tree in the same manner as the narrower one, but designed because of its width to hold enough liquid so that a can to supply solution would be unnecessary. Such a collar, if it held sufficient solution would avoid the additional cost of either returning a crew to collect the cans so they can be used repeatedly, or of leaving such expensive equipment on the trees.

(3) A Metal Collar. The tin collar embodies the same principle and is designed to be used in the same manner as the waxed paper or cardboard, but may possess the superior strength necessary to hold large quantities of solution without collapsing and obviating the use of the supplemental can.

(4) A wick. The suggestion has been submitted that a wick pressed into a saw kerf and connected with a receptacle containing the solution to be absorbed may be found a feasible means of getting a poison solution into the sapwood of a bark beetle infested tree.

(5) An inflated tube. Another suggestion embodies the use of an inflated tube over a saw kerf. After the saw kerf is made the surface above and below is trimmed until a smooth surface three or four inches broad is obtained. The lower edge of a canvas band six-inches broad is held against and around the tree just below the saw kerf by a leather strap which runs through a tubular hem on the edge of band. The deflated rubber tube is then placed against the saw kerf and around the tree with the two ends overlapping. The inflating and injecting valves are arranged to project through openings in the canvas band after which the upper edge of the canvas band is fastened against the tree above the saw kerf in the same manner as the lower edge. The rubber tube is then inflated until it presses against the saw kerf sufficiently to prevent leakage of solution. The canvas band should furnish the necessary counteracting pressure to make a water-tight joint against the saw kerf.

PROJECT IV - A - 2

THE DISTRIBUTION OF LIQUIDS IN LODGEPOLE PINE AS INDICATED BY STAINS

Injecting Stains by the Lipman-Gordon Method.

The object of this experiment was to secure some fairly definite data concerning the distribution of a liquid that is injected into a lodgepole pine. The finding of areas lethal to bark beetle brood above and to a lesser extent below points of injection of poison solution on a few trees and not on others, made it essential that such a study be made before continuing injection experiments. It was also important

to determine the factors that influenced the absorption of solutions and the limitations of the injection method.

Ordinary washing bluing was made into a solution and injected by the method previously used for injecting poison, the Lipman-Gordon method. In some trees the holes were bored just deep enough to tap the sapwood on one side, in others they were bored entirely through and a cork inserted in the far side. Two similar holes, interconnecting, was a still further variation. The treatment and the results secured are given in tabular form.

A Study of Stain Distribution in Green Lodgepole Pine
Using a Solution of Washing Bluing.
East Fork--Bitterroot--1929

Tree Number	Qts. of Solution	Arrangement of Injecting Holes	Date of Injection	Date Examined	Results
S-1	1	One hole entirely thru bole	5/31	6/3	Less than six inches of distribution.
S-2	1	One hole thru sapwood on one side	"	"	Maximum of 6" distribution above and below.
S-3	1	One hole entirely thru	"	"	Less than 6"
S-4	1	One hole thru sapwood on one side	"	"	Less than 6"
S-5	1½	Two holes entirely thru and interconnecting	"	"	Less than 6"

Tree S-3 gave the best distribution of the five treated but it can be seen that six inches diffusion is entirely inadequate. From the results obtained it appears that the solution of washing bluing is a finely divided material from which the coloring material is filtered by the cell walls in the process of absorbing the liquid.

Other staining materials were obtained later from Dr. F. C. Craighead and injected in both green and attacked lodgepole pine. The materials obtained were Eosin Y, Crystal Violet, Acid Fuchsin, and Light Green. The treatment and results follow in condensed form.

Studies of the Distribution of Stains in Green Lodgepole Pine
East Fork-Bitterroot-1929

Eosin Y

Tree Number	Quarts of solution	Arrangement of Injecting Holes	Date Injected	Date Examined	Distribution in Feet Above Point of Injection
E-1	1	One hole thru sapwood on one side	6/14	6/17	Five. None below.
E-2	1	One hole thru	"	6/19	Very faint at 25
E-3	2	Two holes thru and interconnecting	"	6/17	Maximum 20.
E-4	2	One thru sapwood on one side.	"	6/17	About 15.

Crystal Violet

V-1 to V-3	1 and 2	From one thru sapwood on one side to two clear thru and interconnecting.	6/14	6/17 and 6/19	No penetration

Acid Fuchsin

F-1	1	One thru sapwood on one side	6/14	6/19	Five. None below.
F-2	1	One hole clear thru	"	6/17	Maximum of 20.
F-3	2	One thru sapwood on one side	"	----	Not examined.
F-4	2	Two holes thru and interconnecting	"	6/19	Maximum about 32.

Light Green

LG-1	4	Two holes thru and interconnecting.	6/20	7/24	Faint at eight. Only about one downward.
LG-2	4	"	"	"	Faint and small in area.
LG-3	4	Two tangential on opposite sides	"	"	Large in area but only three feet vertically.
LG-4	2	One tangential	"	"	About two.

In no case was there an area stained much in excess of the width of the injecting holes and usually the area was only as wide as the holes

immediately above the point of injection and tapered to a point at the limit of distribution. Distribution was chiefly upward and only downward in a small proportion of the cases. In no instance was absorption by the heartwood observed. From the data secured it is quite definitely established that with green trees the distribution of stains is vertical, chiefly upward. Only in a few cases was it downward and then to a very limited extent. No radial or circumferential diffusion was noted. This limitation to vertical distribution was most noticeable in tree E-4 in which annual rings of the last few years growth were blocked by the inserted cork from the stain and remained unstained to the limit of its distribution.

Two green trees were treated by boring two holes entirely through them at right angles to each other and injecting a solution of picric acid by the Lipman-Gordon method. O ne of the trees showed the characteristic yellow stain to a height of fifteen feet on two sides and eleven feet on the other two sides of the tree. The other tree showed very small stained areas at ten feet indicating that distribution extended only a short distance beyond that point. One tree also showed fading foliage signifying that picric acid, even though showing no visible penetration above fifteen feet, had sufficient toxicity beyond that to cause the death of the foliage.

It might be suggested that the preceding data does not indicate what the distribution would be in an attacked tree. Anticipating such a question some 1928 attacked trees were treated with stains in June of 1929. T he data secured is shown in the following tabulation.

A Study of the Distribution of a Stain in Attacked Lodgepole P ine
East Fork-Bitterroot-1929

Rosin Y

Tree Number	Qts. of Solution	Date Injected	Date Examined	Distribution Above Point of Injection
R-7	4	6/17	7/24	Seven Inches
R-8	4	"	"	Seven Inches
R-9	4	"	6/19	Very little on attacked sides
R-10	4	"	7/24	Eight inches above, twelve below

W here attack had been heavy and bluestaining general as in the trees just discussed, there was very little distribution of the injected stain, while on the sides having no attack by bark beetles the best diffusion of stain was obtained. Apparently advanced stages of blue stain greatly retards the conduction of liquid.

From the preceding data it appears that length of time since attack and the amount of blue stain influence the distribution of staining materials injected in an attacked tree. It is possible therefore that spring control work by injecting poisons will be found generally ineffective even when a satisfactory technic is developed. Fall control work closely following attack or at most during early spring may be the only periods when such a method will be found effective.

Injecting stains by the Saw-Kerf Method.

From results obtained by the previously discussed methods of staining it seems obvious that the method of injecting which has been used has been faulty. P oison solutions have been taken up and quite generally distributed over the inner sapwood of the tree but in

insufficient quantities or entirely lacking in the outer rings where it would be effective in controlling the brood. To overcome this condition Dr. F. C. Craighead suggested a method of injecting materials into the outer growth rings of a tree; the saw-kerf method described in the first part of the report. By the use of such a method the value of the different solutions of poisons as control mediums can be gauged as it was believed the poisons would be brought in direct contact with the mountain pine beetle brood where it feeds between the bark and the wood.

The method was tried, following the procedure outlined in the first part of this report and using a green stain. In spite of care taken to prevent it, considerable leakage developed around the injecting band. Wholesale use of tacks and grease finally stopped most of the leakage but demonstrated that the method needed considerable improvement before it could be recommended as a control measure. Measured in effectiveness of distribution the method was a vast improvement over previous practice, showing general distribution and rapid absorption of the solution. Notes on the rate of absorption made by two trees indicated that the solution was taken up at the rate of about one pint an hour. Examinations of the trees injected showed the green color of the stain not only over the entire bole but even in some of the limbs of the tree. Such favorable results from a stain gave promise that a poison solution injected by the same method would come directly in contact with and control brood of an insect feeding between bark and wood. Subsequent experiments using this same method with sodium arsenate, described under Project IV-A-1 of this report, showed excellent control.

Injection of Materials by Means of a Spile

Mr. J. C. Evenden of the Coeur d'Alene Station believed injection might be accomplished effectively by means of a spile, a heavy, hollow, tapered piece of metal built on the plan of a modified hypodermic needle. It was believed that such a piece of apparatus could be driven into a tree and connected with a can containing a poison solution, with little expenditure of time and effort. If successful the method would be cheap and the apparatus could be used repeatedly. Such a spile was constructed and experimented with in the summer of 1929. In this piece of metal a tangential depression was made near the point at right angles to the length of the spile, which intersected a hole drilled through the center. This hole did not extend the full length, ending near the point, where the depression intersected it. The point was ground sharp to facilitate driving it into a tree. A small hole was drilled in the side of the tube until it tapped the central hole and far enough from the larger end to prevent interfering with driving. Into this hole a small copper tube was fitted for the purpose of connecting the spile by means of a rubber hose with a can containing the solution to be injected.

The method of using the spile was to drive the pointed end into the sapwood of a tree until the depression near the point was well into the wood. The shoulder nearest the point, left when the depression was made, was designed to force back and hold the wood tissue, opening up a small space for contact with solutions coming through the hollow center of the spile. The shoulder on the other side, left in making the depression, served to press against the wood and prevent leakage.

The injecting material used was a solution of stain. It was found that the distribution was both limited and slow and that leakage was difficult to stop. While the exact cause of the poor distribution is not known, it is thought to be due to the small area of saywood tissue exposed and to possible impairment of the conducting tissue through crushing caused by driving the spile into it. Absorption vertically was only about 12 inches and none occurred radially or circumferentially.

Considerable difficulty was experienced in withdrawing the spile from the tree, due to the shoulder near the point functioning in somewhat the same manner as the barb of a fishhook.

The many features of this apparatus and method which were found unsatisfactory make it inadvisable to consider experimenting further with them.

PROJECT V -A - 4

DICHLORICIDE AS A CONTROL MATERIAL FOR THE MOUNTAIN PINE BEETLE

This material (P aradichlorobenzene or dichloricide) was suggested as a material that might control barkbeetle brood when dissolved in gasoline and used as a spray. A solution of about one-quarter of a pound in one quart of gasoline was sprayed on the bole of a freshly attacked tree, using a hand sprayer. The solution as applied in the form of a heavy mist to a height of seven feet on the bole, thoroughly saturating it, it was hoped the gas from the spray would penetrate the bark and kill the infesting brood which was in the parent adult and egg stages. A subsequent examination of the tree did not reveal any control of the insects. T his treatment was tried initially on July 26 and repeated on the same portion of the same tree on August 8, using a similar proportion of gasoline and chemical but double the quantity. A thorough soaking of the bark showed no effect on the brood when the tree was subsequently examined. It is not believed this material is effective against the mountain pine beetle in the manner in which it was used, and no further experiments with it as a spray are recommended.

It is hoped, however, that during the 1930 season this experiment can be repeated using orthodichlorobenzene which it is believed offers possibilities of control.

PROJECT VI - A - 3
TRAP TREES

In an effort to secure a trap tree that would attract the mountain pine beetle a number of methods were tried. On each of May 31 and June 21, 1929, five green lodgepole pine of a size susceptible to bark-beetle attack had a band about four inches broad scorched completely around the tree a short distance above the base. The scorching was done with a blow torch. These trees averaged about ten inches in diameter and those in the first group were heated for varying lengths of time. The following tabulation gives the time each tree was exposed to the heat.

GREEN LODGEPOLE PINE HEATED WITH A BLOW TORCH TO ATTRACT MOUNTAIN PINE BEETLE
1929

Tree Number	Minutes Exposed to Blow Torch Flame	Date Treated
X -1	3	May 31
X -2	2	"
X -3	6	"
X -4	5	"
X-5	5	"
X -6 to X -10	15	June 21

Examinations of the effect of treatment were made on July 24, 29, and August 5, 1929. No insects had attacked the trees neither had they attacked trees within fifty feet of them prior to August 5. It is believed these observations are indicative of the failure of the treatment as a trapping method.

In another experiment green trees of susceptible size were treated by injecting a solution of one-half an ounce of sodium arsenate in a quart of water into each tree. For absorbing the solution variations of the L ipman-Gordon method were used. In two trees a one-inch hole and in the other two two interconnecting holes of the same size were bored entirely through them. These trees were treated on May 31. On June 21 the experiment was duplicated with a second group of four more trees. On July 10 a tree in the first group showed attacks to a height of 6 feet and egg galleries 5 to 6 inches long, indicating that the attack had occurred at least 5 or 6 days previously. Observations on July 19 showed more attacks in the same tree and in nearby untreated trees. One other treated tree of the first group showed a few attacks at the base by both Dendroctonus murrayanae and Dendroctonus valens, but no mountain pine beetle attacks. On July 24 a third tree of the first group treated showed a very light attack which did not increase in amount later. A few Dendroctonus valens also attacked this tree. The four trees of the second group treated on June 21 did not show attacks at any time. From these observations it is apparent that trees treated in this manner cannot be considered successful trap trees as the insects made a normal attack on only one tree out of eight treated. The treatment does seem to be slightly attractive to Dendroctonus murrayanae and Dendroctonus valens, bark-beetles not usually considered serious pests.

Project VI - A - 7

BROOD DEVELOPMENT OF DENDROCTONUS MONTICOLAE IN LODGEPOLE PINE

East Fork-Bitterroot River-1929

Brood development in 1929 was abnormally rapid in the latter part of June in spite of the early part of that month having been quite cold. That such a speeding up actually occurred is shown by a comparison of the length of time required for development of the brood from the 20 to the 70 per cent new adult stages for 1929 and the two preceding years. In the tabulation given below is seen data derived from curves made of the development for these three years.

BROOD DEVELOPMENT OF THE MOUNTAIN PINE BEETLE

Period of Time Required for Development from 20 to 70 Per Cent New Adult Stage

In 1927	In 1928	In 1929
June 21-July 8	June 21-July 3	June 24-July 1
Days Required-17	12	7

The figures show that the time required for the same amount of development in brood in 1929 was little more than half the amount needed in 1928 and only about 40 per cent of that for 1927.

A curve was constructed showing the general development of the mountain pine beetle in 1929 and may be found at the end of this report. From this curve a table was made showing the development of the beetle brood by intervals, the first two of 10 days each and the remainder of 5 days each. The table which follows also indicates the average brood number per square foot and the ratio of potentially emerging brood to the number originally

attacking for each period.

BROOD STATUS FOR VARIOUS DATES
DENDROCTONUS MONTICOLAE IN LODGEPOLE PINE (1)
EAST FORK - BITTERROOT - 1929

Date	Per cent of Each Stage				No. of Brood per sq. ft.	Ratio-Brood to attacks
	Larvae	Pupae	New Adults	Emergence		
5/22	100	--	---	---	153	7.1
6/1	100	--	---	---	101	4.7
6/11	93	5	2	---	70	3.3
6/16	85	12	3	---	59	2.8
6/21	63	27	10	---	50	2.4
6/26	21	52	27	---	43	2.0
7/1	6	29	65	---	37	1.7
7/6	3	4	93	---	31	1.4
7/11	3	1	96	---	26	1.2
7/16	2	1	97	---	21	1.0
7/21	--	--	92	8	18	.8

(1) Data from 34 control trees

From the figures just given it is seen that the potentially emerging brood is slightly less than the number attacking.

Under Project VI - A - 3 in this report it is stated that attack of a trap tree likely took place about July 4 or 5 while in the preceding table no emergence is shown until after the 16th of July. The discrepancy is due to site. The attack on July 4 or 5 occurred on what is believed to be the warmest site in the general region and is not believed to be typical of the Bitterroot Drainage. The figures given in the preceding table are believed to be more representative of general conditions.

SUMMARY

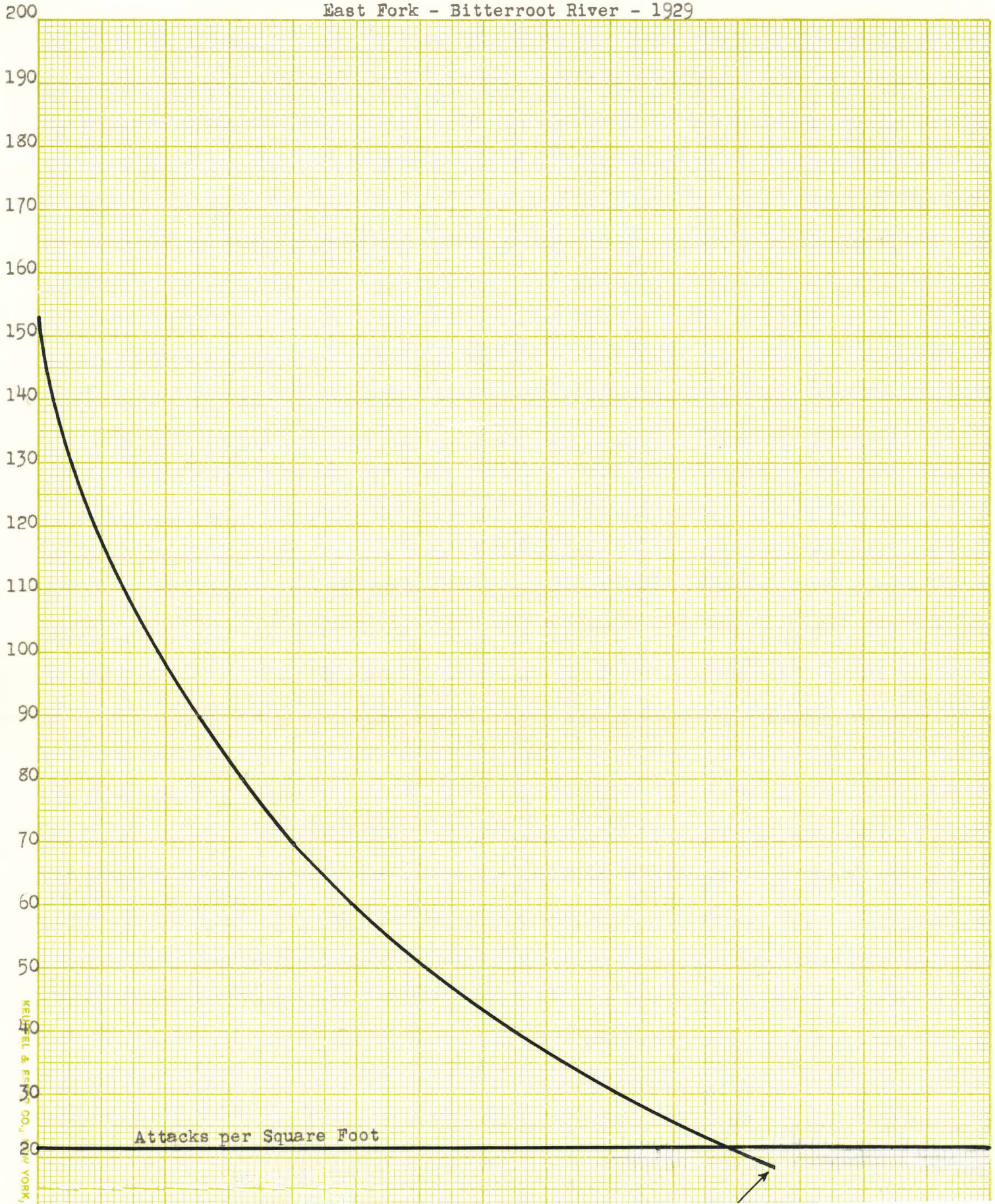
This summary contains brief statements of the more significant results obtained from the studies discussed in this report. None of the injection experiments using the Lipman-Gordon method were more than partially successful in controlling the brood. Some chemicals gave no indication of being lethal to the insects. Those showing definite control properties were sodium arsenate, potassium cyanide, and carbon disulphide. Experiments in which injection of poisons was effected by the saw-kerf method gave good control but both the equipment and technic of application need perfecting.

Injection of stains in infested and green trees revealed the defects of the Lipman-Gordon method and the advantages of the saw-kerf method. Stain injection also showed a limitation of this injection method in the length of time it can be used by revealing the slowness and very limited distribution of stains when injection is attempted after the brood has completed most of its development. The liquid transporting functions of the tree may be slowing up with approaching death, blue stain may be clogging the translocation streams, or possibly a combination of both is responsible for the slow and limited absorption. If additional experiments in 1930 substantiate this finding it will mean that control by injection must be confined chiefly to the season of attack and possibly to early spring of the following year.

Injection of stains by this method also showed the necessity of injecting materials in the outer growth rings of the tree if they are to be effective in controlling infesting bark beetle brood.

Trap trees failed to induce mountain pine beetle attacks but were found slightly attractive by secondary bark beetles.

Brood per Square Foot on Different Dates
Dendroctonus Monticolae in Untreated Lodgepole Pine
East Fork - Bitterroot River - 1929



KEUFFEL & ESSER CO. NEW YORK

Salmon JMS 3-6-31 WM
Targhee LWS 3-9-31
Caribou [illegible] 3/13/31
Wyoming [illegible] 3/17/31 MD
R. 0 - F M file

F. S. D-4
RECEIVED
MAR 18 1931
FOREST MANAGEMENT
And...

FOREST SERVICE
TARGHEE NATIONAL FOREST
ST. ANTHONY, IDAHO
MAR 9 1931
RECEIVED
Answered

FOREST SERVICE
SALMON NATIONAL FOREST
SALMON, IDAHO
FEB 27 1931
RECEIVED
Answered

FOREST SERVICE
WYOMING NATIONAL FOREST
KEMMERER, WYO.
MAR 16 1931
RECEIVED
Answered

FOREST SERVICE
CARIBOU NATIONAL FOREST
MONTPELIER, IDAHO
MAR 11 1931
RECEIVED
Answered

February 25, 1931.

S
Insect Control

Mr. James C. Evenden,
Forest Insect Field Station,
Coeur d'Alene, Idaho.

Dear Mr. Evenden:

I have again gone over carefully Mr. Gibson's "Progress Report No. 4 - Investigations Concerning the Mountain Pine Beetle in Lodgepole Pine" transmitted with your letter of March 27, 1930.

This is an excellent report and we certainly appreciate your thoughtfulness in sending us copies and sincerely hope you will keep it up.

It looks as though the poisoning method of control will not compete at the present time at least with burning methods, but the investigations are developing so much fundamental data that it is sincerely to be hoped that they will be carried through to completion. We can never tell whether or not methods can be used commercially until the facts are ascertained. Usually, sooner or later, commercial methods can be developed. At least we should know what we can not do.

It would seem that, with relation to Project V-A-3, as reported in this manuscript, a start has hardly been made in the study of attraction. It seems to me that further work along this line should be pushed. This is fundamental work.

Project VI-A-7:

I don't understand all I read on Pages 31 and 32 on brood development. However, that's my fault. The period of development data seems to parallel our studies in the development of forage plants on the range, i.e. in early seasons the forage starts early and in late

O. C. L.

Mr. J. C. E.

seasons late but the late starts seem to catch up as the season goes on and there seems to be little variation in the date of seed maturity, etc.

Does the "Brood Status" table indicate that with a ratio of brood to attacks of 7.1 on May 22 that we can reasonably expect this will be naturally reduced to a ratio of .8 by July 21 or by time of emergence? It is unfortunate that we can not study the same brood clear through the period. I would think that it will be necessary to build up a mass of data on this point covering several years.

Let's have more fundamental research.

I am routing this manuscript to the Salmon and other Forests interested.

Very sincerely yours,

C. B. Morse

Assistant Regional Forester.

Salmon
Taylor

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
WASHINGTON, D. C.

U. S. D.
RECEIVED
MAR 29 1930
FOREST MANAGEMENT
Ans.

FOREST ENTOMOLOGY.

Refer to file
Studies L-7

Forest Insect Field Station,
Coeur d'Alene, Idaho,
March 27, 1930.

Carbon
Wyoming - MD
Reg Off nm file.

District Forester,
Forest Service Building,
Ogden, Utah.

Dear Sir:

We are enclosing a report by Mr. Gibson entitled "Investigation Concerning the Mountain Pine Beetle in Lodgepole Pine". We would be very pleased to have your comments on this report and trust that it will be of interest to you.

Sincerely yours,

James C. Evenden

James C. Evenden
Entomologist.

1 encl.